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COMMA CLOUD DEVELOPMENT RELATED TO MAJOR WINTER STORMS - TWO EX-ETC(U)

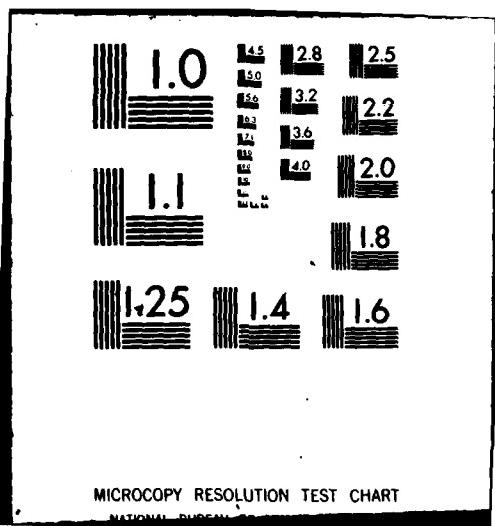
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**COMMA CLOUD DEVELOPMENT RELATED
TO MAJOR WINTER STORMS-
TWO EXAMPLES**

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THIRD WEATHER WING
OFFUTT AFB, NEBRASKA 68113

3 MARCH 1980

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FOR THE COMMANDER

Daniel R. Gornell

DANIEL R. GORNELL, Lt Col, USAF
Chief, Aerospace Sciences Division

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Midwest	Snowstorm																
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <p>This Technical Note discusses the relationship of comma cloud development over the southern Rockies and plain states to the developing storm system. Emphasis is placed on the likelihood that the storm system will soon recurve northeastward when the comma cloud becomes well-defined. A brief look at the structure and the development of the comma cloud is included. Two case studies are presented.</p>																	

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INTRODUCTION

Comma cloud development associated with two short wave storm systems that occurred during the past year is presented in this Technical Note (TN). These two dynamic systems produced a variety of weather over large sections of the central CONUS. A comma cloud is indicative of a positive vorticity advection (PVA) maximum. When a PVA maximum approaches a surface disturbance the associated lifting will cause further development of the disturbance. Therefore the approach of a comma cloud formation is often a precursor of storm development. One of the problems faced by forecasters is the ability to predict when and where the developed storm system will recurve towards the northeast. We present two cases illustrating recurvature occurring just after the comma cloud becomes sharply defined in the vicinity of the surface disturbance; this is evident in both case studies. Perhaps forecasters with GOES satellite data may be able to use this information to predict recurvature of storms emerging from the Rockies. Forecasters who do not have a GOES or WFSO tap can still identify comma clouds on the synoptic scale by using satellite charts transmitted over the NWS facsimile network.

STRUCTURE AND DEVELOPMENT OF THE COMMA CLOUD

Before we discuss these two comma cloud events let's take a brief look at the structure and development of the comma cloud. The following information was extracted from two excellent publications on the application of satellite data (see references).

From "NWS Satellite Training Course Notes, April 1975", by R. B. Weldon: Figure 1 depicts a typical vorticity comma pattern. Weldon (1) uses the term "Vorticity Comma" to describe the comma shaped cloud patterns.

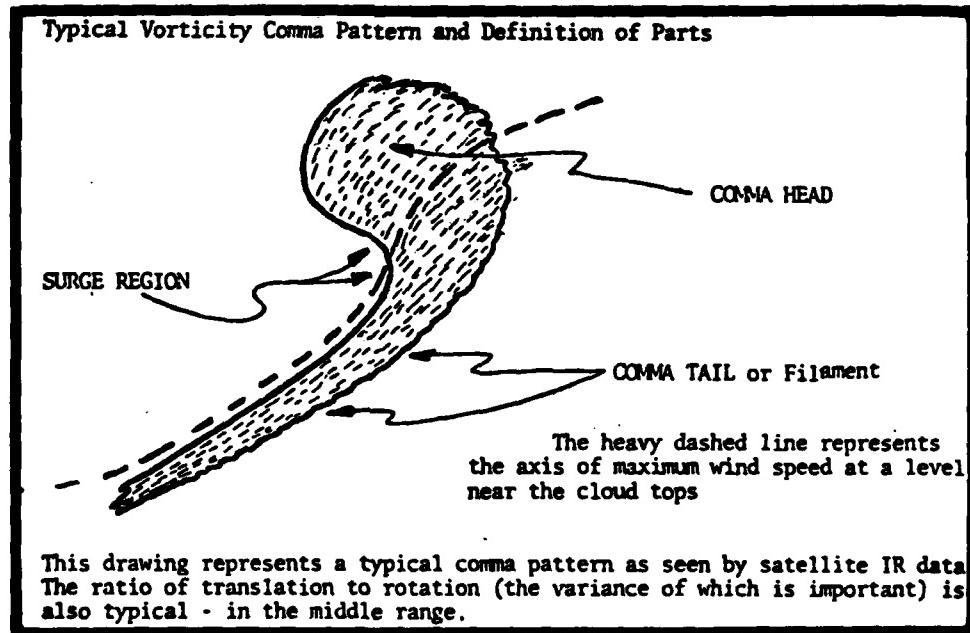


Figure 1

Definitions:

The "Surge Region": This is the area of the comma pattern where the translation of the back cloud edge is large. If you visualize the pattern undergoing a twisting motion, the area indicated as the Surge Region would be moving northeastward most rapidly while the part to the left would be lagging and tending toward rotation. The part to the right would also lag with perhaps a more distinct cutoff between rapid movement and lag.

The Comma Head: That portion of clouds to the left of the axis of maximum wind speed. This portion tends to lag and shows the most tendency for rotation.

The Comma Tail or Vorticity Filament: That portion of the cloud pattern which

trails out to the rear on the right side of the Surge Region. The Comma Tail becomes parallel to the axis of maximum winds with its edge just to the right of the axis. Note that the winds referred to are at or near the cloud top level. The wind speeds may increase with height to reach a 3-dimensional maximum far above the cloud top level. This upper level max - the jet axis - may not have the same relation to the lower level.

The clouds associated with these comma structure are often mid-level clouds.

The best indicator of the strength of the comma cloud system is the distinctiveness of the cloud system, not the overall size of the system, not the type of clouds, not the height of cloud tops involved.

When a system is strengthening, the cloud edges become better defined on all sides, however, the front side is likely to be feathered with plumes of debris (but they are also likely to cut off more distinctly at the ridge line).

From "Using Satellite Imagery to Detect and Track Comma Clouds and the Application of the Zone Technique in Forecasting Severe Storms" by Colonel Robert C. Miller, USAF, Ret and John A. McGinley (some of this information has been paraphrased):

Comma cloud systems are associated with frontal boundaries and frontal exit areas at mid and upper levels in the troposphere (Figure 2). The comma cloud identifies the zone of concentrated upward vertical motion and concentrated positive vorticity advection, associated with a short wave embedded in the westerlies. Comma clouds become increasingly well defined in the mid tropospheric frontal exit area in a zone ahead of which low level frontogenesis is taking place, Figure 2.

The west or upwind edge of the comma separates downward motion from upward motion to the east or downwind. The downward motion drives high speed upper level air to the surface. In a sense, the comma represents an upper front with potentially cool air to the west or upwind and warmer air to the east, Figure 2.

The comma may first appear as a thin line, a blob, cluster or an elongated band. The comma will become better defined with time and when it moves into the frontal exit area it often appears as a spiraled cloud mass, Figure 3. Occasionally a PVA maximum will not attain the distinctive comma cloud shape but will still initiate convective activity as it approaches and moves over favorable lower tropospheric features, Figure 4.

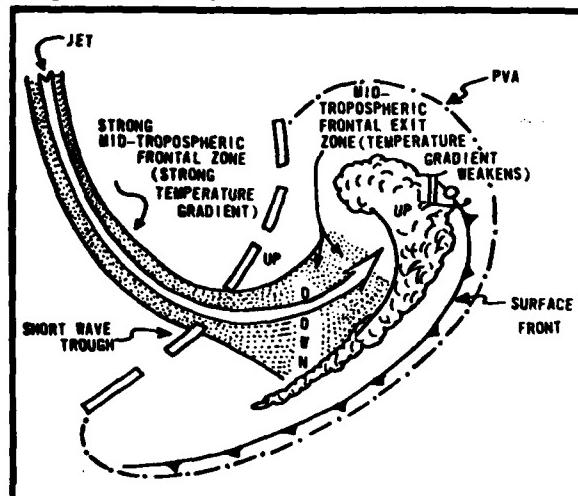


Figure 2
Comma Cloud and Associated Features

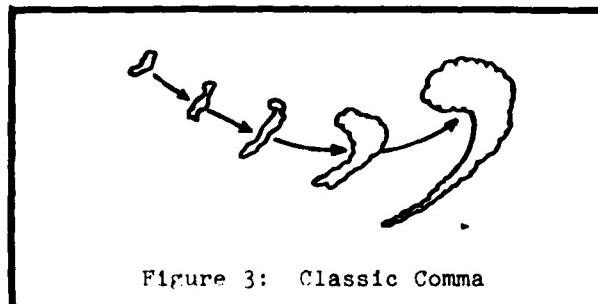


Figure 3: Classic Comma

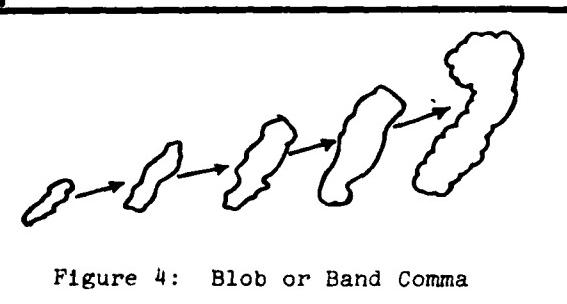


Figure 4: Blob or Band Comma

When the mid and upper tropospheric levels are too dry to support cloud formation the comma cloud is initially invisible, appearing only when thunderstorms develop. In these instances conventional data must be analysed and close watch maintained for the first signs of line-cloud development on the satellite imagery. For example, a region of PVA shown on an LFM prog should be watched for this development. If the position of development disagrees with the prog, then the prog should be adjusted. Observation shows that such initial cloud development is evident 2 or 3 hours prior to radar indications. As thunderstorms increase and transport low level moisture to

mid tropospheric levels, the comma shape becomes visually evident, Figure 5.

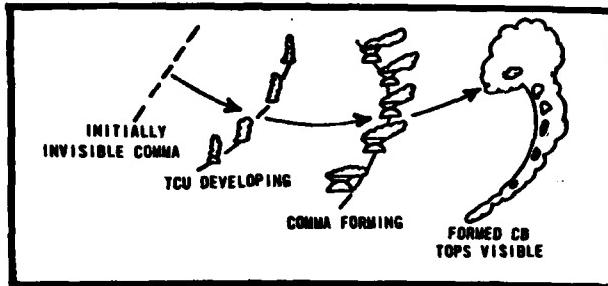


Figure 5: Invisible Comma

When cirrus clouds exhibit a comma shape, we expect a very high level density and wind discontinuity, which may or may not be reflected at lower levels. The changes in cloud distribution seen in a series of satellite images are related to the approach, interaction, and passage of comma cloud systems. When comma structures represent deep zones of density discontinuity, they will usually dominate the surface patterns, eventually producing a strong occluded cyclone with rapid air motion through a very large volume of the troposphere. This is consonant with theoretical dynamic meteorology.

The comma head is always north of the main polar jet and overruns air that may be marginally unstable by the standards, discussed in AWSTR 200. However, the comma head is the focal point of the major dynamic atmospheric adjustments and is associated with the strongest PVA and most rapid horizontal cold advection aloft.

A comma shaped cloud mass approaching an open surface frontal wave is often associated with an upstream speed maximum embedded in the main polar jet. The surface low development can be seen in the improved definition and sharpness of the advancing comma cloud mass.

COMMA CLOUD EVENT 1 - 3 MARCH 1979

Cyclogenesis at 500mb within an eastward - moving short wave over Arizona occurred by 12Z 2 March (Figure 6). Subsequent 12-hour 500mb analyses (Figures 7 and 8) depict low movement across the southern Rockies and plains states - an ideal track for subsequent storm development over the central plains. Twelve hour height falls and centers (X) are shown. This system recurved over northern Texas on 3 March as indicated by the height fall center (HFC) movements in Figures 7 and 8. Following HFCs and their magnitude changes to determine system recurvature is discussed in detail in 3WW TN 79-2, Major Midwest Snowstorms.

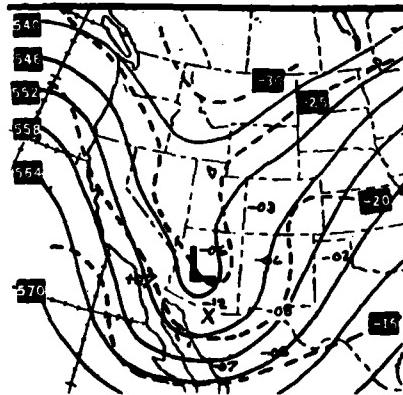


Figure 6: 1200Z 2 Mar 1979

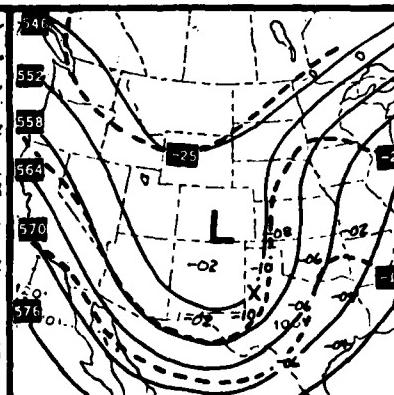


Figure 7: 0000Z 3 Mar 1979

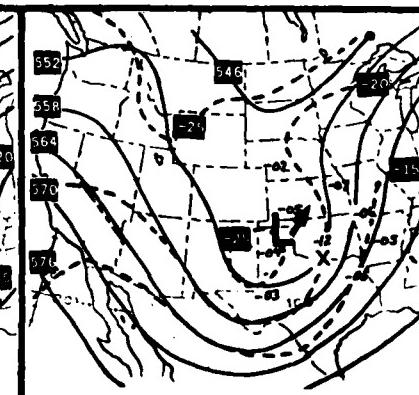


Figure 8: 1200Z 3 Mar 1979

500MB ANALYSES

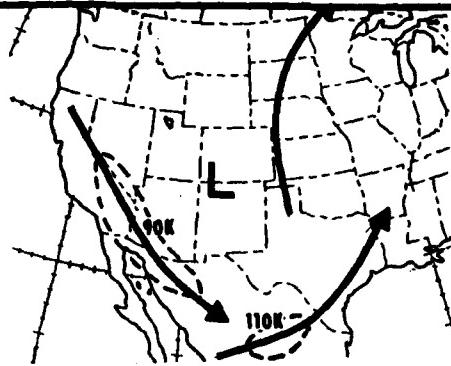


Figure 9: 0000Z 3 Mar 1979

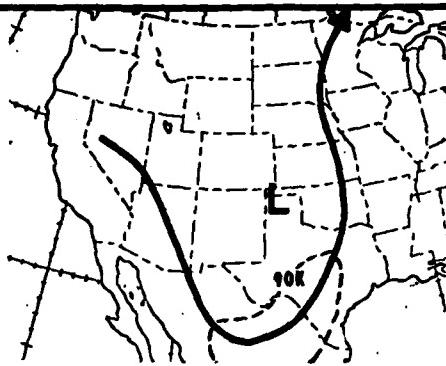


Figure 10: 1200Z 3 Mar 1979

300MB ANALYSES

Figures 9 and 10 show 300mb jet stream positions during and after recurvature. The jet strengthened and shifted eastward across the central plains by 12Z 3 March (Figure 10).

Surface charts during recurvature are shown in Figures 11, 12 and 13*. In Figure 11, an extensive precipitation area is occurring from Texas northward to the Dakotas. The main surface low is shown over the Texas Panhandle which relates to the 500mb low in Figure 7. Six hours later (Figure 12), a new low appeared over north-central Oklahoma ahead of the Panhandle low. As will be shown later, the Oklahoma low will become the dynamic low; the Texas low will dissipate to be replaced by cold polar air from the central Rockies. Identification of the primary surface low is sometimes difficult when several lows exist within the development area. Maintaining continuity on vorticity and height fall centers can help determine where the primary low will appear or develop.

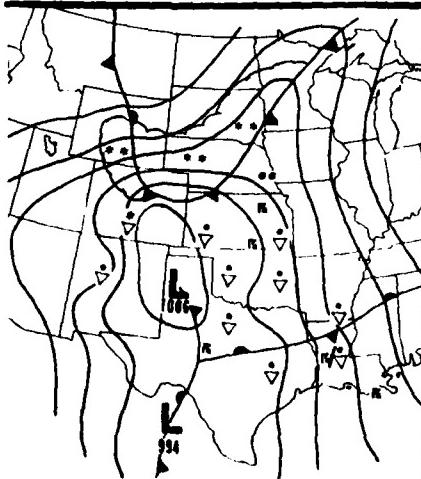


Figure 11: 0000Z 3 Mar 1979

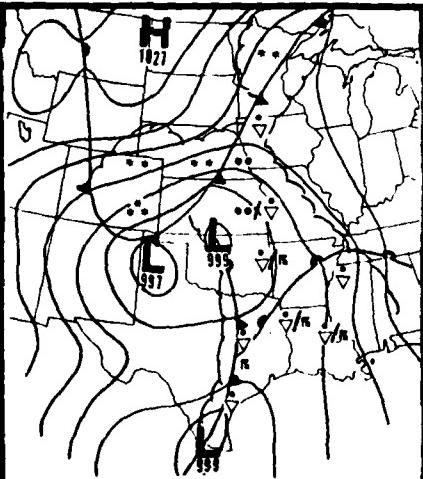


Figure 12: 0600Z 3 Mar 1979

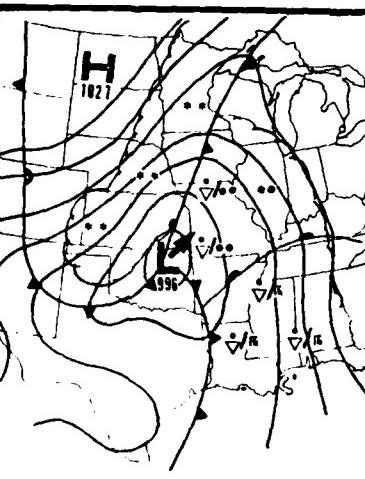


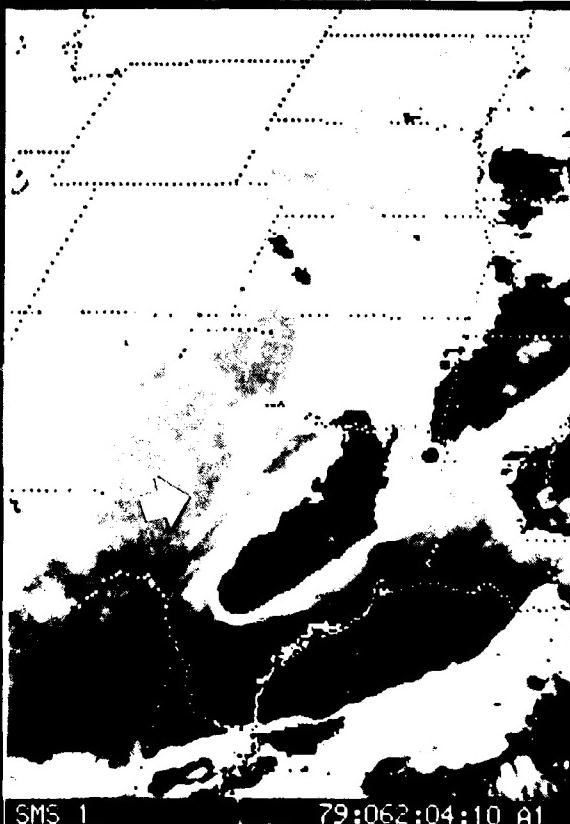
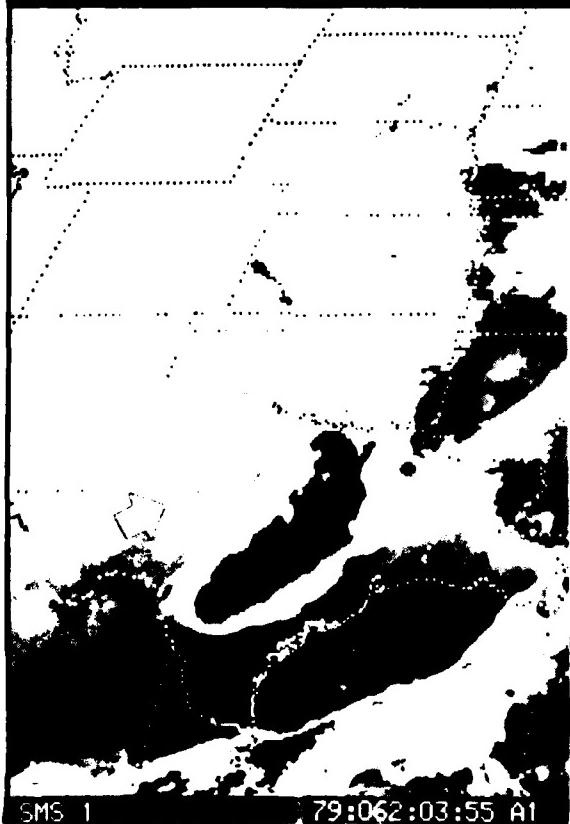
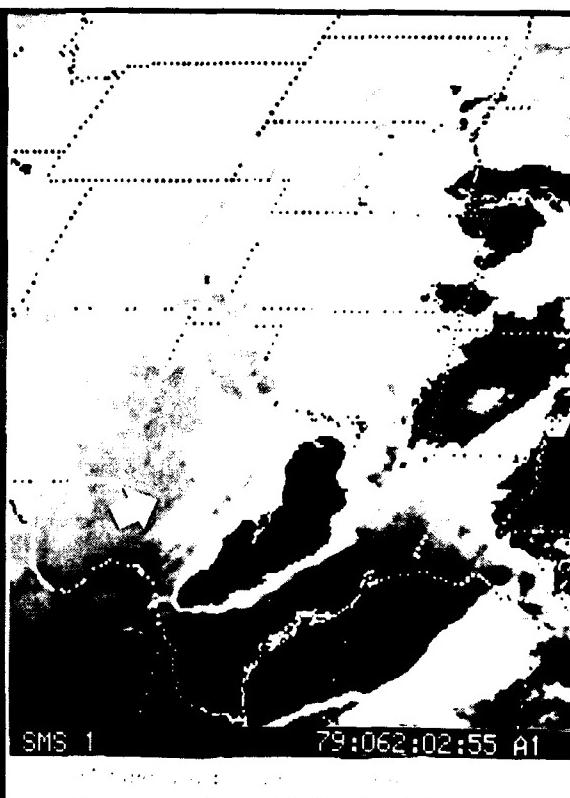
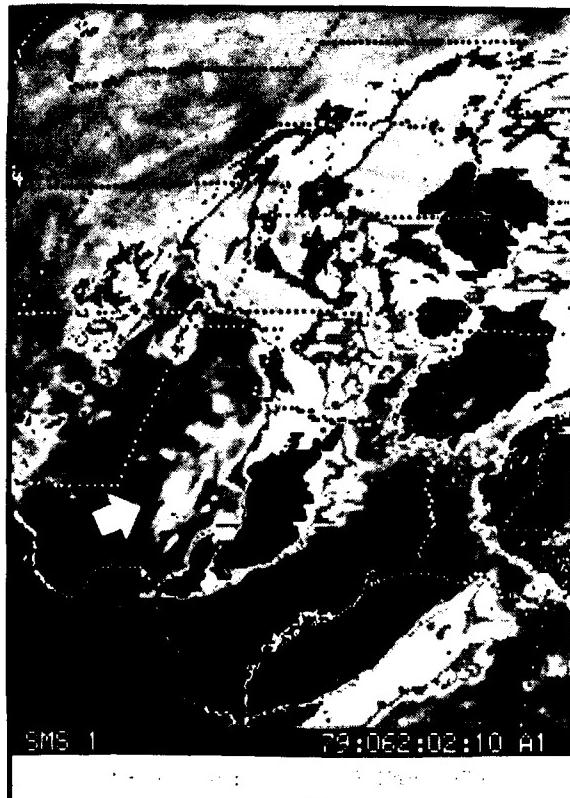
Figure 13: 1200Z 3 Mar 1979

SURFACE ANALYSES

Recognition of certain cloud features on satellite charts provides forecasters with another tool in the possible identification of system recurvature. In this case study and the one that follows, satellite charts depict comma cloud development over New Mexico and northern Texas during and several hours before system recurvature. These comma clouds became well-defined during and after the bottoming out period (see figure 3).

Figure sequence 14 (a, b, c, d) shows the development of a comma cloud (white arrow in figures) over western Texas within a 2-hour period. Thunderstorms are occurring east of the developing comma cloud. In Figure 14d (3/0410Z), the comma cloud has become fully developed. The comma head is approaching Childress, TX (CDS) (Figure 14d) and is in agreement with the vorticity center track shown in Figure 15 (from the LFM 500mb initial analyses).

* All analyses shown in this TN were copied exactly from NWS facsimile analyses.



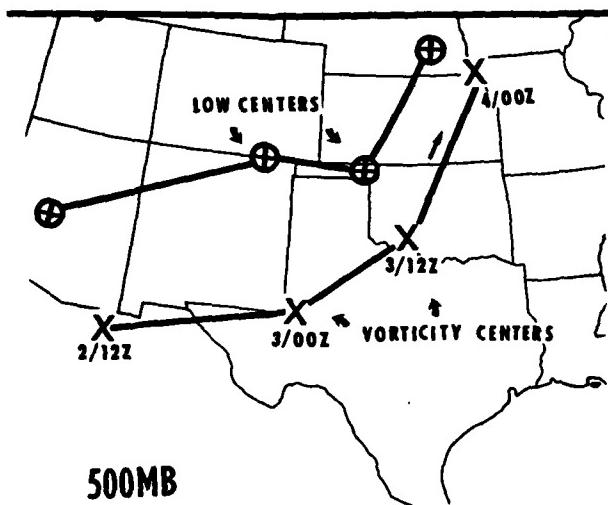


Figure 15: 500MB Low and Vorticity Tracks
2-3 March 1979

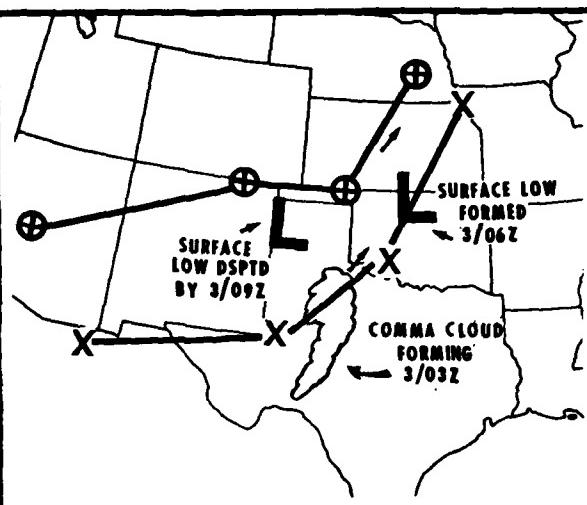


Figure 16: Composite, 2-3 March 1979

Figure 16 relates the developing comma cloud with surface low positions at 06Z 3 March and the two tracks shown in the previous figure (Figure 15). Note the low pressure formation over north-central Oklahoma 3 hours after the comma cloud formed. As mentioned earlier, the Texas Panhandle low dissipated. This storm system moved north-eastward to Missouri and produced heavy snowfall from the Nebraska - central Kansas area and westward.

COMMA CLOUD EVENT 2 - 30 OCT 1979

This system is similar in development to the one just described. In this case however, the recurvature area and the appearance of the comma cloud were located further to the west than shown in Case 1. A 500mb low developed within a short wave over Nevada at 12Z 29 Oct (not shown). Subsequent low development and movement are shown in Figures 17 through 21. System recurvature occurred by 00Z 31 Oct as shown in Figure 19.

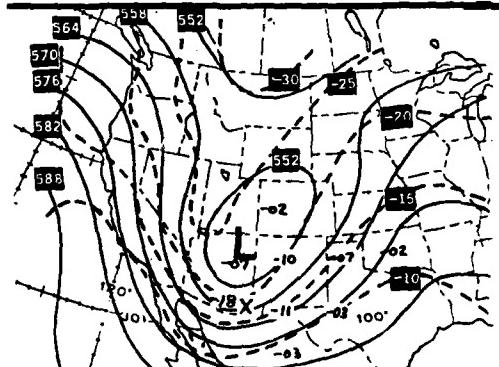


Figure 17: 0000Z 30 Oct 1979

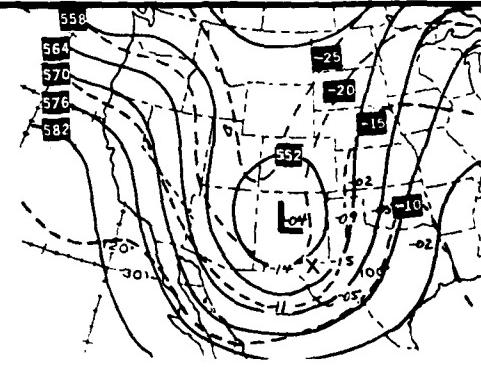


Figure 18: 1200Z 30 Oct 1979

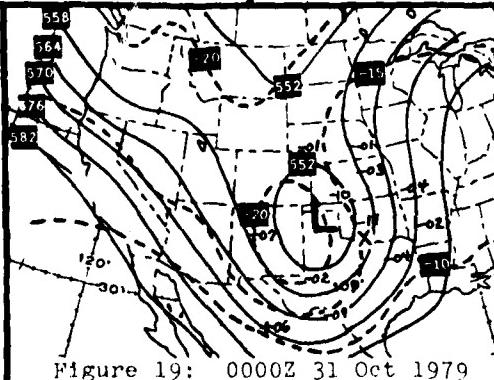


Figure 19: 0000Z 31 Oct 1979

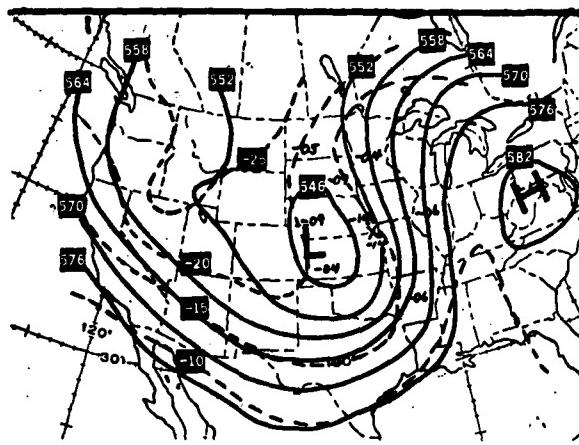


Figure 20: 1200Z 31 Oct 1979

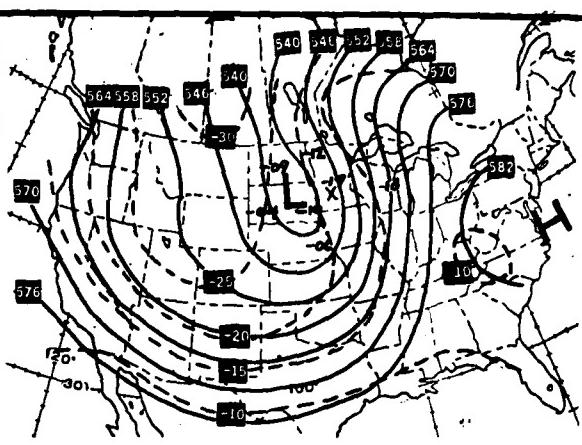


Figure 21: 0000Z 01 Nov 1979

500MB ANALYSES

Jet stream positions (300mb) during the recurvature period are shown in Figures 22 and 23.

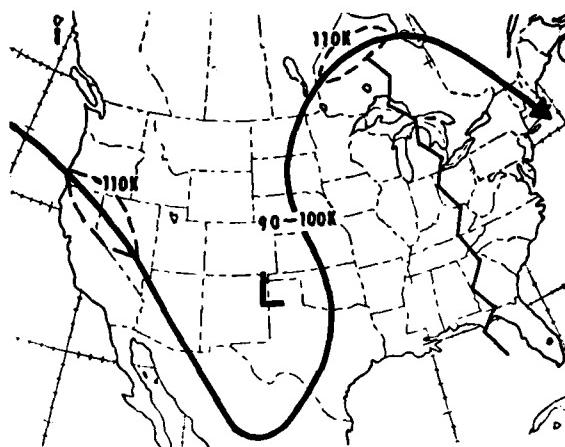


Figure 22: 0000Z 31 Oct 1979

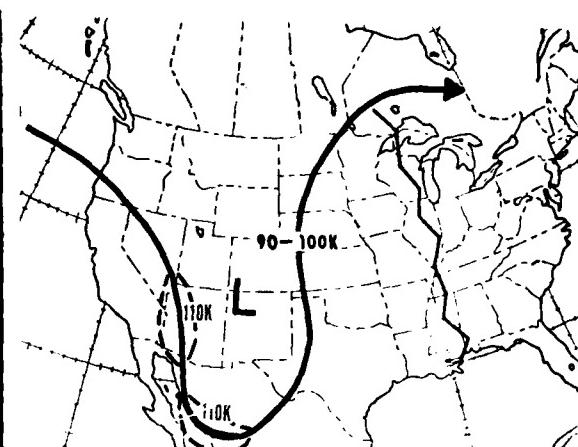


Figure 23: 1200Z 31 Oct 1979

300MB ANALYSES

Surface low development and its subsequent intensification over the southern plains are shown in Figures 24 through 26.

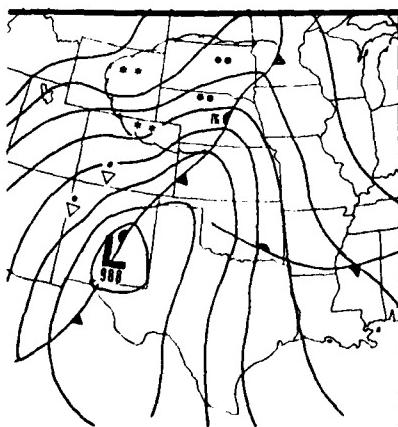


Figure 24: 0000Z 30 OCT 1979

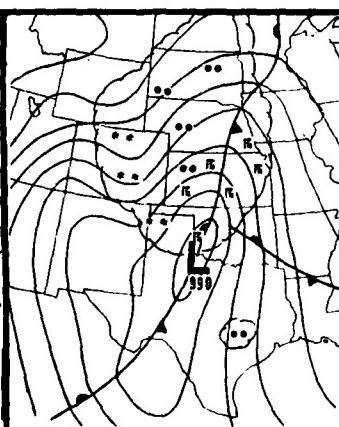


Figure 25: 0900Z 30 Oct 1979

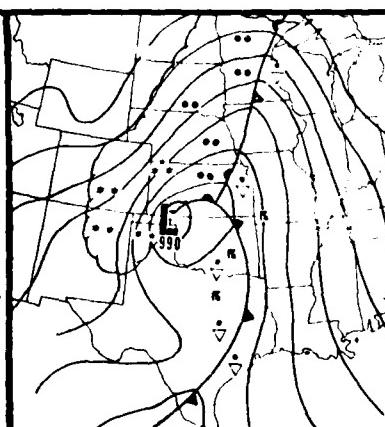


Figure 26: 2100Z 30 Oct 1979

SURFACE ANALYSES

Figure sequence 27 (a, b, c) and Figure 28 shows the developing comma cloud (see white arrows in each figure). The comma is well defined over eastern New Mexico as shown in Figures 27b and 27c. By 1745Z 30 Oct (Figure 28), the comma-shaped cloud is not noticeable. Apparently the cloud move northeastward and weakened or has merged with the frontal cloud system shown over the central plains.

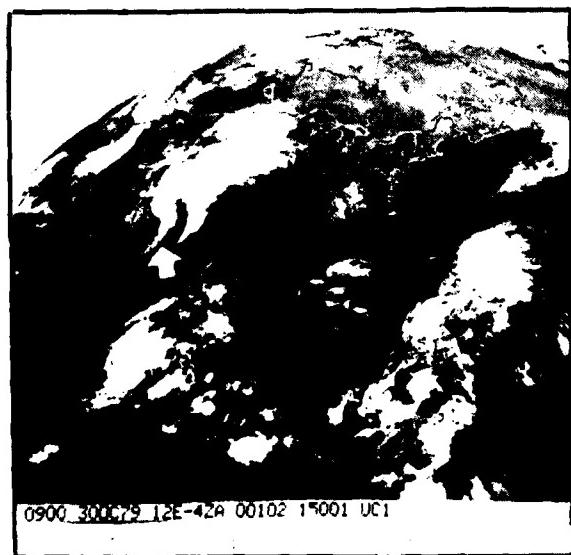
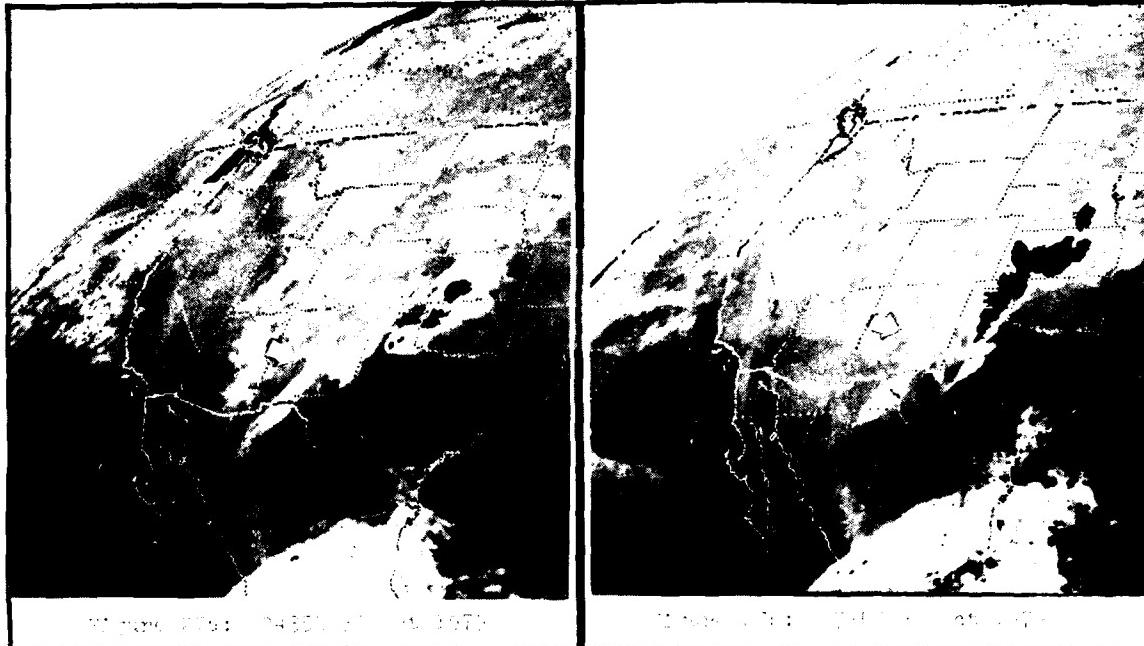




Figure 28: 1745Z 30 Oct 1979

The 12-hour vorticity and 500mb low center tracks (from the LFM analyses) are shown in Figure 29. Recurvature is evident over the eastern New Mexico - Texas Panhandle region. These two tracks were included again, along with the 30/0900Z comma cloud and surface low positions, in a composite chart (Figure 30). The comma head appears with the 500mb low center rather than the vorticity center. The comma tail is ahead of the 30/12Z maximum vorticity center. The heavy dashed line in Figure 30 is the axis of maximum vorticity which usually coincides with the rear of the PVA area (1).

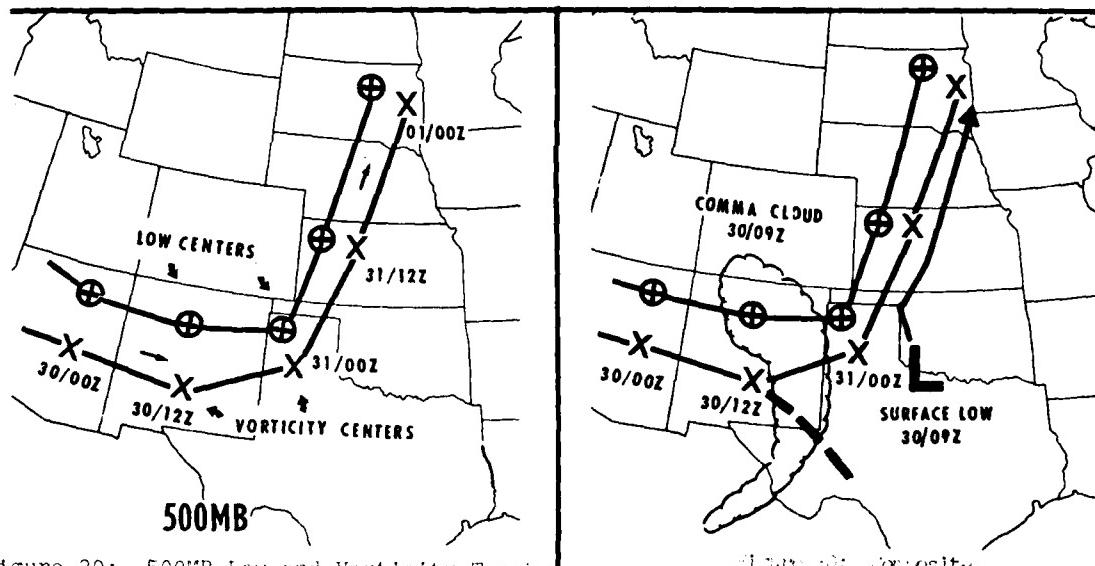


Figure 29: 500MB Low and Vorticity Tracks
30 Oct - 01 Nov 1979

Figure 30: Composite,
30 Oct - 01 Nov 1979

Note the good comma cloud definition just prior to recurvature. A few hours later, the surface system began to move northward as shown in Figure 30. The occlusion process occurred between 00/1800Z and 00/1900Z AST. This system produced heavy snowfall over eastern Colorado, northwestern Kansas and western Nebraska.

SUMMARY

Forecasting the recurvature path of storm systems originating from the Rocky Mountains has proven difficult for the midwestern forecasters, but this information is vital to correctly forecast the onset of heavy snow, rain, thunderstorms, etc. The two studies presented tend to verify previous observations that storms recurve after being influenced by a well defined vorticity comma. If this proves valid after more intensive study, forecasters with access to satellite data will be able to predict the storm path with greater accuracy. Meanwhile, forecasters should observe the event and use the concept cautiously.

REFERENCES

- (1) Weldon, R. B., 1975: Satellite Training, Part 1, Basic Cloud Systems, *NWS Course Notes*, pp 2-6.
- (2) Miller, Robert C. and McGinley, John A., 1978: Using Satellite Imagery to Detect and Track Comma Clouds and the Applications of the Zone Technique in Forecasting Severe Storms, *General Electric*, pp 2-1 - 3-15.

All satellite pictures courtesy of Air Force Global Weather Central.